THE IMPACT OF THE COVID-19 PANDEMIC ON THE US SHALE INDUSTRY: AN (EXPERT) REVIEW

by
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Abstract

The US shale industry turned the world-wide energy landscape upside down in less than a decade and put the US (back) atop the global energy hierarchy. At the beginning of 2020, the Covid-19 pandemic shocked the global energy markets and led to an unprecedented economic downturn. US shale oil & gas demand plummeted, prices collapsed, and bankruptcies were announced at exceptional rates. This paper aims to assess the impact of the virus and its repercussions on US unconventionals. For that, this study focuses on six central drivers highly relevant for the industry and its future viability. These are: First, crude oil and natural gas prices. Second, Break-Even (BE) prices for fracking operations. Third, financial and technical constraints within the industry. Fourth, global hydrocarbon demand development. Fifth, political and regulatory factors in the US. Sixth, environmental and societal sustainability. Those drivers were initially assessed through a literature review whose results were then examined by an expert survey. It was comprised of 83 senior professionals from various backgrounds engaged with the US shale industry. From a synthesis of both examinations, the results show that some drivers, in particular demand and commodity prices, are shaping the industry's future more distinctly than others. It further seems that while those drivers are also impacted substantially by the pandemic, they positively influence the future of the industry. In contrast to the literature review, the survey also revealed that most experts expect the industry to recover to pre-Covid-19 levels. While these results are quite noteworthy, uncertainty displays a thread throughout this assessment. The future US and global energy landscape projection is extremely complex, and its drivers are interconnected. Therefore, this study aims to highlight some basic considerations regarding the forces at work while considering that some future implications can change the picture fundamentally - just like Covid-19 itself did.

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List of Abbreviations

BBL	Barrel
BE	Break-Even
Bn	Billion
CMV	Common Method Variance
GDP	Gross Domestic Product
EIA	US Energy Information Administration
EPA	US Environmental Protection Agency
ESG	Environmental, Social, and Governance
EV	Electric Vehicles
FERC	US Federal Energy Regulatory Commission
IEA	International Energy Agency
IMF	International Monetary Fund
IQR	Interquartile range
IOC	International Oil Company
LCOE	Leveraged Costs of Energy
M&A	Mergers & Acquisitions
M	(Arithmetic) Mean
Mdn	Median
NIMBY	Not In My Backyard
MMBtu	One million British Thermal Units
NGL	Natural Gas Liquid
Q.	Survey question
ROI	Return on Investment
VMT	Vehicle Miles Travelled
WTI	West Texas Intermediate

1. Introduction

At the beginning of the century, experts forecasted a dead-end for unconventionals and considered the US doomed to be dependent on foreign hydrocarbons, in particular gas, for a very long time (FERC, 2003). Only two decades later, the same country became a net exporter of energy (EIA, 2020b). Never has US natural gas production and consumption been as high as in 2019 (EIA, 2020a). At the same time, its reserves are considered to last for at least another 100 years (Sutton et al., 2010). Being the world's largest oil producer (IEA, 2020b), "project independence"[1] finally became a reality. Oil & gas from shale formations disrupted the global energy landscape and turned out to be the most immense energy innovation in this century so far (Yergin, 2020). Until early 2020, the US shale industry's evolution was an almost perfect success story prima facie. Then came March 2020.

Just before Covid-19 spread through the continents, crude oil supply boomed (by then mainly driven by Russia, Saudi Arabia, and US shale, particularly from Texas). Simultaneously, demand, which was relatively inelastic before, collapsed as rapidly as the world's economies. West Texas Intermediate (WTI), the crude most US companies are heavily dependent on, fell by more than 50% in March. It later went negative for the first time in history (EIA, 2020f). Since then, US shale companies' revenues have decreased by more than 60% from the prior quarter (Williams-Derry et al., 2020). In the first half of 2020, the number of US oil & gas rigs, which is a barometer for industry vigor, almost split itself into thirds (Baker Hughes, 2020). While half of the US shale companies are under significant insolvency risk (Dickson et al., 2020), more than 200 already filed for bankruptcy (Haynes and Boone LLP, 2020) which underlines the industry´s financial challenges. The IEA suggests that it will take

[1] "Project Independence" was a policy goal announced by President Nixon in the 1970s as a reaction to the oil crisis at that time. It aimed at the US being independent of other countries to cover its energy demand but was never reached (and some still doubt if it really was) until 2019.

years until global demand recovers to pre-crisis levels – if it will ever reach that high again (IEA, 2020b). Even though any future developments in the time of a global pandemic are highly uncertain, one thing already seems to be clear: Covid-19 has had an enormous and unprecedented impact on the industry. This work aims to have a closer look at what this impact looks like in detail and its consequences for its future.

Based on the fundamental literature on shale (Amongst others: Gao & You, 2017; IEA, 2019, 2020b; Mehany & Guggemos, 2015; Wang, Chen, Jha, & Rogers, 2014), six key drivers that are decisive for the future of the US shale industry stand out: First, crude oil and natural gas prices. Second, Break-Even (BE) prices for fracking operations. Third, financial and technical constraints within the industry (e.g., debt ratios, capital spending, competition). Fourth, global hydrocarbon demand development. Fifth, political and regulatory factors in the US. Sixth, environmental and societal sustainability. The assessment of these factors as indicators for the state and US shale industry's future begins with a concise literature review. From that review, two central hypotheses are derived: First, the impact of Covid-19 for the industry is negative. Second, 2019 was an all-time industry high in terms of activity and production not to be reached again. These hypotheses are then examined (verified or falsified) through an expert survey whose methodology and results are discussed subsequently. This work will close with a discussion section, followed by a conclusion.

2. Literature Review

Due to the fast-moving nature of many of the trends presented subsequently, not only scientific literature but also various publications from other, non-peer-reviewed sources will be utilized. The succeeding literature review closely examines the six central drivers presented in the introduction. Its key mechanisms, as well as its repercussions pre- and post-Covid-19 are stated in detail for every driver and then summarized. Derived from that, the following two hypotheses are generated:

H_1: The impact of Covid-19 for the industry is negative

H_2: 2019 was an all-time industry high in terms of activity and production not to be reached again

2.1. Crude oil and gas prices

The prices for crude oil & gas[2] are essential for the shale industry. Based on the BE for fracking operations (discussed in 2.2), they decide about such projects' economic viability. Both, being commodities traded globally, are principally depending on the global mechanisms of supply and demand. After 2008, gas prices started to decouple from crude oil and did not necessarily go parallel anymore (Aiube et al., 2017). Their relationship became more indirect and variances for one commodity price are not necessarily translated into the other (Hartley & Medlock, 2014). Although, crude oil prices still exert a prominent influence on those of natural gas (Brown & Yucel, 2008). That is particularly true during price shocks (Jadidzadeh & Serletis, 2017) and still very applicable in the States since a lot of US oil originates in Natural Gas Liquids (NGL). Although, still being the world's central commodity, oil price parameters go beyond the traditional steering through supply and demand and also reflect a great variety of additional factors (Kallis & Sager, 2017; Kilian, 2009; Lumsdaine & Papell, 1997; Rapaport, 2012). That is even more true in the times of a pandemic (Mensi et al., 2020). These factors need to be taken into account when discussing future prices and therefore are included subsequently.

[2] References to prices relate to WTI for oil and Henry Hub for natural gas. Those linkages are used throughout the entire work.

The concept of "peak oil" is more and more replaced by the state of "energy abundance" (Van de Graaf & Sovacool, 2020). Supply skyrocketed pre-Covid-19 (IEA, 2019). Low prices in April and May 2020 also occurred due to oversupply: OPEC+ did not manage to agree on cuts, which led to producers upscaling their volumes. With the oil revenues crucial for many state budgets, several nations could not and still cannot afford shutting down production even further, especially since other income sources are affected by Covid-19 as well. The same applies to many privately-owned companies that, facing financial hardship in the times of a global pandemic, need to keep operations going to cover their fixed costs. Such excess supply could keep prices low (Fitch Ratings Ltd., 2020; Guliyev, 2020). The pandemic itself imposes adverse effects on oil prices (Mohammed & Barrales-Ruiz, 2020).

On the contrary, 81% of global wells are already in decline, and without US shale, currently making up around 8% of the global oil output, vast supply gaps would occur rapidly (Michaux, 2019). The pandemic put many operators out of business and made outages peak in the first half of 2020 (EIA, 2020f). Consolidation could decrease volumes for a longer period (Avraam et al., 2020; Liu & Li, 2018). Still, supply is rather going to increase slightly within the next years (Rystad Energy, 2020) in order to catch up with global demand (discussed closer in 2.4), which plummeted in the first half of 2020 for oil. Gas remained more stable (EIA, 2020e), although it was hit hard by the pandemic-caused economic decline. Even though the energy transition will diminish demand, it will probably increase from a medium-term perspective with the transition fuel natural gas clearly advantaged (IEA, 2020b). That could lead to a more stable price plateau within the next years.

Oil prices dropping from just about \$60/bbl at the beginning of 2020 could average around \$35/bbl this year and increase to \$45/bbl in 2021 (Fitch Ratings Ltd., 2020). Almost half of the executives interviewed in the Dallas Fed (2020) Energy Survey expect the year to end with prices of \$40/bbl – \$60/bbl. Rystad Energy (2020) expects \$60/bbl as a long-term equilibrium with prices gradually increasing within the next years. Jefferson (2020) considers an increase to a range from \$40/bbl – \$60/bbl as feasible. As of late fall 2020, prices headed into that corridor with listings well above \$40//bbl. While natural gas prices did not necessarily support a struggling industry when the Covid-19 effects took place, prices are more likely to go up heading into 2021 (EIA, 2020f) and in the medium to long-term (Dickson et al., 2020; Habrich-Böcker et al., 2015). All these assumptions are being made under “normal” conditions of linear market movements.

A key acknowledgement is that volatility increases even though prices will probably go up again in the medium-term. What Covid-19 proved is that such normal conditions of linear supply and demand curves barely exist anymore. No one saw the pandemic coming. However, even without shocks by singular events, markets are increasingly volatile (Michaux, 2019; Van de Graaf & Sovacool, 2020) and can already observed to be. Up- and down-cycle frequency is increasing (Rystad Energy, 2020). For instance, oil markets had to face three major price shocks within the last 12 years, on average, every five years.

In such an environment, additional parameters are becoming increasingly important (Bhattacharyya, 2011): How is OPEC (+), and more importantly, how are the big three (Yergin, 2020) Russia, USA, and Saudi Arabia regulating supply? Will Saudi Arabia be willing to be the global swing producer in the future? How are geopolitics evolving? How does (global) storage facility develop in order to balance fluctuation? How are investments into gas infrastructure evolving? As Jefferson (2020, p.2) emphasizes, the above explanations are “no attempt to prophesy or forecast, but simply to indicate some forces at work and guesses as to where they might lead”. Covid-19 fostered two trends: Even though prices will recover in the medium-term, a fast rebound of energy prices is unlikely even in the post-pandemic era (Grigas, 2017). Moreover, volatility increases even though prices will probably rise again in the medium-term. Both apply to a greater extent for oil than for gas. Nevertheless, these developments do not necessarily display a strong future price foundation for the shale industry as a whole.

2.2. Global hydrocarbon demand development

For the substantial drop in crude oil prices in spring 2020, two major factors came together. One was, as discussed in 2.1, oversupply. It was accompanied by plunges in global demand as the world economy shut down. While global crude oil demand declined by roughly 30% in the first half of 2020 (IEA, 2020b), some products were carried down by that and then impacted even harder. Gasoline demand fell by 50% in the US and by 65% in Europe (EIA, 2020a).

Natural gas demand, mainly utilized in more crisis-resilient sectors like heating or residential electricity, remained more stable and is expected to go down by 3% in 2020 (IEA, 2020b). That is also based on the relatively low price plateau natural gas touched prior to 2020 due to oversupply of this global commodity. Nevertheless, US industrial gas demand is likely to decrease by 20 % in 2020 (EIA, 2020c).

Global demand development is very challenging to forecast due to the many uncertain future factors to predict. In most scenarios, global oil demand will increase over the next decade but peak somewhere between mid-2020 and 2040 (BP p.l.c., 2020; EIA, 2020a; IEA, 2020b; Tsoskounoglou et al., 2008). Natural gas, fueling the energy (or low carbon) transition, will be needed for a much longer time, and capacity will be added at considerable rates in the short-term (EIA, 2020a). However, vast gaps exist between the different scenarios (BP p.l.c., 2020). Depending on the pace of the global low-carbon transition and regulatory policies, natural gas demand in 2050 could be twice as big in a "business as usual" in comparison to a "net zero" scenario (BP p.l.c., 2020). Vehicle Miles traveled (VMT) in the US collapsed by more than half, in some places in the world, almost minus 75% by late spring 2020 (Highway &

Administration, 2020; Statista, 2020; Tomer & Fishbane, 2020). Even though traffic recovered recently, VMTs will be 20% lower than in 2019 (Highway & Administration, 2020). The aviation industry is hit even harder: For 2020, global enplanement numbers are expected to fall by 55% to pre-year, while recovery to pre-crisis levels will take until 2024, according to the IATA (2020). US refinery output was down by 20% pre-year (EIA, 2020d), which points at the fuels affected most by the pandemic: jet and gasoline (Larsen et al., 2020), which account for almost 60% of accumulated demand (Jefferson, 2020). Even though it should be mentioned that US domestic demand is only partly affected by that tendency since the US refinery system relies on heavier crudes. Well above 50 % of heavy crudes e.g., from Saudi Arabia, are imported (EIA, 2020a) and US refineries only partly can work with domestic, lighter crudes. Therefore, global demand for US exported crudes is a slightly more demand-driving factor here.

Oil is a key resource for civilization because the transportation sector, which is vital for every other sector from food supply to industry, depends almost entirely upon it (McNally, 2017). Although the same sector is the one most affected by Covid-19 (IEA, 2020b). The world could get used to a "new normal" that is shaped by remote work, localized or disrupted supply chains, regionalization, lower levels of international trade, greater reliance on digital channels, and even the return of borders (Brakman et al., 2020; Dickson et al., 2020; McKinsey & Company, 2020). These trends hurt the transportation sector and lessen its oil demand. For instance, one-third of all workers switched to remote work by late spring 2020 (Brynjolfsson et al., 2020), and almost half of US jobs could be done remotely (Dey et al., 2020). Even though oil is not substitutable (Löschel et al., 2020), future disruptions in transportation like the increase in ride-sharing and EVs could hurt demand even further.

Nevertheless, these predictions are characterized by enormous uncertainty, and a whole variety of factors can be applied to either foster or harm future demand (IEA, 2020b). Although oil demand is not expected to return to pre-pandemic levels anytime soon, in most future scenarios, it is going to recover (BP p.l.c., 2020; Crooks et al., 2020). However, so will gas. Oil's abrupt fall has narrowed the oil-to-gas price ratio from 50 in 2012 to less than 10 in April 2020 (Dickson et al., 2020; EIA, 2020f). Heightening volatility in the oil market, relative stability due to heating, industrial usage and fueling the intensifying electrification of the energy sector, as well as a projected fall in associated gas production due to the cut in oil drilling, will strengthen natural gas demand (BP p.l.c., 2020; Dickson et al., 2020; IEA, 2020b). Since conventional sources will hardly satisfy future demands (IEA, 2020b; Melikoglu, 2014), the Covid-19 might turn out to have strengthened the case for US shale gas from a medium to long-term perspective. Gas was less affected by Covid-19, and the pandemic therefore accelerated a trend that already was described as the "New Fuel Order": Natural gas' rise to become the number one fossil fuel.

2.3. BE prices for fracking operations

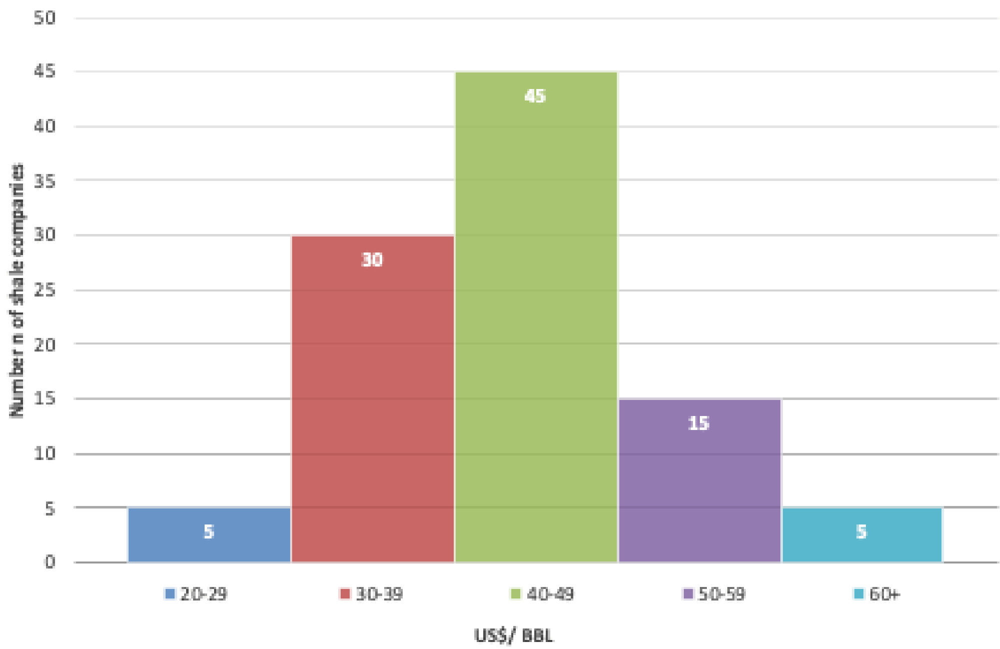
BE prices for fracking operations are, in interplay with the market prices discussed in 2.1, decisive for such projects' economic (and in particular financial) viability. They determine both the competitiveness of shale projects as well as their Return On Investment (ROI) and therewith the attractiveness for investors. In recent years, shale has become increasingly competitive and the industry adapted to the drop in oil prices around 2014. They grew leaner and decreased their BEs through technology enhancements, improved well output and cost reductions. Technology breakthroughs like big well drilling or "walking drill rigs" have continuously improved efficiency and grew sourcing rates by double-digit numbers (Konduc et al., 2020; Wethe, 2015). On the other hand, major challenges remained. The output of a fracked well decreases steeply after year one, sometimes as much as 50%. Therefore, companies need to add new wells frequently to ensure sufficient productivity, which is more cost-intensive. Many older assets generate lower outputs than expected if put close together, known as the "Parent-

Child-well problem". Therefore, wells are dug further apart, leading to fewer total wells and lower outputs, which often leads to write offs in the books (Rafiee & Grover, 2017). Those asset write downs are one of the main reasons why the industry reported net losses of $6.7bn in 2019 (Williams-Derry et al., 2020).

Today, shale gas has unlocked abundant resources at BE of less than $2.5/MMBtu to $3.0/MMBtu (Barbosa et al., 2020) and is considered to be ahead of shale oil in terms of cost discipline and competitiveness what also led to lower decline rates (SailingStone Capital Partners, 2020). US shale oil breaks even at around about $50/bbl for new wells on average (Dallas Fed, 2020; Dickson et al., 2020), while the number is roughly half of that for existing operations (Dallas Fed, 2020). However, the variance in BEs through different geologies and regions can be substantial (Dallas Fed, 2020). Hydrocarbons from the Permian are more competitive than those from Bakken, which means that the dynamics described in this chapter apply even more for products and companies originating in the latter. Figure 1 gives an overview of the BE costs of the one-hundred largest shale companies (oil) in the US.

The intense, immediate effect of Covid-19 on prices discussed in 2.1 exerts pressure on producers to become leaner and more efficient in order to be able to withstand even lower prices (Scholl, 2019). With current price levels of shale oil just above $40/bbl, most producers do not necessarily break-even but could continue operations for multiple years (Dallas Fed, 2020). Those who will not be able to do so could become victims of a major market consolidation (Dickson et al., 2020; Scholl, 2019). As the number of Mergers and Acquisitions (M&As) increased (Habrich-Böcker et al., 2015), it was boosted by the pandemic.

Figure 1 - *BE costs of the 100 largest fracking companies in the US*



Source: *Rystad Energy, Dallas Fed*

2.4. Financial and technical constraints within the industry

Even before the Covid-19 pandemic hit the industry, financial and technical strains were on the rise. By 2025, the industry is expected to have accumulated \$86bn in debt with net negative free cash flows of more than \$300bn since 2012 (Alam & Wood, 2020; Dickson et al., 2020). Outstanding liabilities and dependence on venture capital are an issue. Even prior to 2020, oil & gas companies underperformed the market, in parts because the focus was on growth and securing market share (Barbosa et al., 2020; Dallas Fed, 2020). Even in an increased price scenario of \$50 -\$60/bbl, only a few companies were profitable recently (McLean, 2018). In the price scenarios described in 2.1 and 2.2, only 25%-50% of producers will remain solvent (Dickson et al., 2020).

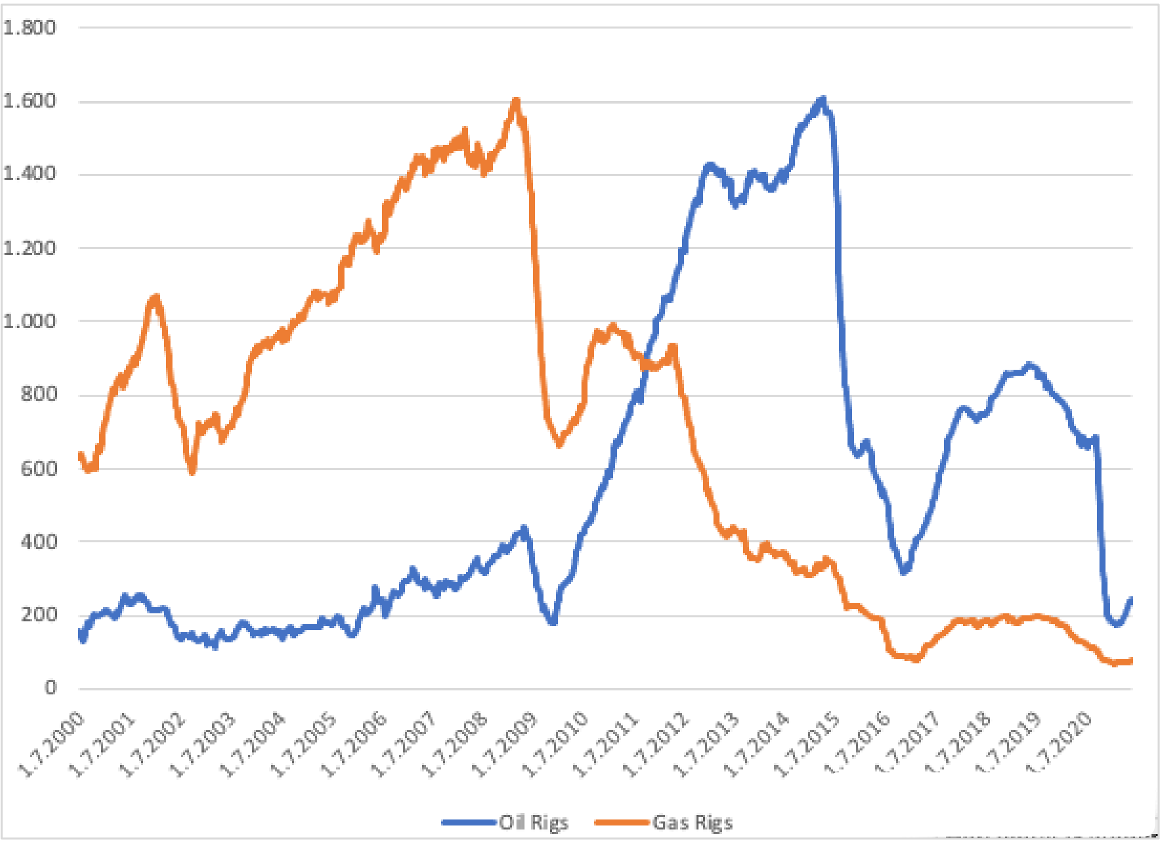
The corresponding risk premiums increase (Aiube et al., 2017; Teti et al., 2020). Covid-19 put investments on hold and forced investors even further to take on a long-term perspective (McKinsey & Company, 2020), which fostered uncertainty regarding the industry's future path. The IEA (2020b) estimates that US shale will suffer a 50% decline in investment activity in 2020 since investors are hesitant to fund further ventures in low price environments. While it is expected that investments in hydrocarbons decline in the times of price shocks (Bjørnland & Zhulanova, 2019), the hundreds of bankruptcies appearing in the last years (Dickson et al., 2020; Haynes and Boone LLP, 2020), volatile markets, and a lack of reasonable returns for investors (Williams-Derry et al., 2020) make investments less attractive in a time when needed most. Declining Capex and plunging market capitalization make it even harder for struggling companies to pay off their debts and could lead to additional bankruptcies (Williams-Derry et al., 2020).

It is crucial for shale companies to increase their focus on profitability to ensure a sufficient stream of investor money in the future. That is particularly true for pension funds and other institutional investors searching for suitable investment targets in a decade of low-interest rates but might review their strategies in the uncertain post-Covid-19 era. Major international oil companies (IOC) like Chevron and Exxon entered the market recently, which put operations on a firmer foundation and enabled entities to also get through periods of market hardship (Scholl, 2019). Nevertheless, increased competition and investor skepticism will probably shape the next years in the US shale industry.

So will the number of bankruptcies. More than 200 shale producers already filed for Chapter 11 bankruptcy (also known as reorganization bankruptcy) (Haynes and Boone LLP, 2020), among them significant players like Chesapeake Energy, once a S&P 500 company. More than half of the current shale oil companies are at risk (Dickson et al., 2020) to suffer the same fate. While this is a harmful development leading to business closures and worker layoffs in the short term, it could strengthen the industry from a medium perspective, sparing only those who own healthy operations and financials. Indeed, looking at the US oil & gas rig count, which can be interpreted as a predictor for future output, two things stand out: The decline followed after the 2014 price drop was much steeper, even though it occurred over a more extended period (Baker Hughes, 2020). Second, the number of new wells targeted increased slightly recently (Baker Hughes, 2020) while the output of both shale oil and gas recovered in fall 2020 (EIA, 2020f).

Therefore, it is doubtful that the consolidation process is already completed. Still, many operators state growth and new wells as their top priority instead of consolidating their business, which partly led to the pre-Covid-19 oversupply (Dallas Fed, 2020). Figure 2 displays the US rig count for the last two decades.

Figure 2 – *Total number of US oil & gas rigs from 2000 to present*



Source: *Baker Hughes*

Moreover, chapter 11 bankruptcy does not remove players (and volumes) from the market for long. That results in the assumption that market consolidation is likely going to continue, burdening many operators, especially smaller independent ones (Scholl, 2019). From a medium-term perspective, this could decrease BEs, which would benefit the industry that is currently disadvantaged at low-price periods compared to other hydrocarbon developments (Rystad Energy, 2019). This might partly be balanced out by the short cycle character shale has compared to other projects, e.g., offshore and applies particularly to companies with low adjustment costs (Foroni & Stracca, 2019).

2.5. Political and regulatory factors in the US

The political repercussions of the US shale boom were extensive. First of all, being the world's biggest hydrocarbon producer and a net exporter of energy (IEA, 2020b) is a substantial achievement in foreign policy and diplomatic freedom. Energy independence is a huge political capital and will shape US policies (e.g. Nordstream 2 or the Iran sanctions) and entire world regions (e.g., the Middle East) dramatically. Moreover, shale's economic impact was vast. It reduced the US trade deficit by more than $200bn (Witte et al., 2018) and addressed more than 40 % of cumulative growth in us industrial production from 2009-2019 (Yergin, 2020). Cheap shale gas made heating and electricity very affordable in international comparison (EIA, 2020a), which was beneficial for consumers and foreign investment into the US, such as manufacturing or chemical production. It added jobs and prosperity (Porter et al., 2015; Solarin & Bello, 2020; Weber, 2012), often in regions that lacked those (e.g., the Appalachian or the Bakken shale). Although, local economic benefits are often smaller than expected (Bilgili et al., 2020; Kinnaman, 2011). The links between local GDP developments and their impact vary, depending on the region and its development history (Bilgili et al., 2020). Conditions and influences in the Texas Permian are fundamentally different in comparison to South Dakota's Bakken. Drops in housing prices next to fracturing sites (Keeler & Stephens,

2020) and the collapse of local infrastructure in shale boom areas (Scholl, 2019) demonstrate some of the downsides. The societal and environmental license discussed in 2.6 displays an immense political factor. Political and regulatory statutes have the potential to shut down the entire industry as seen in the state of New York who banned such activities entirely. NIMBY (Not In My Backyard) attitudes and environmental protests seek to address the political rejection of shale (Dahl, 2015).

The most significant impact on the regulatory and political side will certainly be exerted through government change after the 2020 US presidential election. While a stable policy environment is crucial for the industry's wellbeing (Scholl, 2019), many industry executives already expressed their concerns about a Biden administration tightening regulations for the industry (Dallas Fed, 2020). It is already clear that Biden promised to ban fracking on federal land, although that applies to little above 10% of the overall fracking activities. Other than that, not much is known yet. While Covid-19 has considerably impacted the election outcome (Pew Research Center, 2020), it is relatively uncertain which policies the new administration will adopt when it comes to the energy sector. A lot also depends on the results of the special elections for the US senate held in Georgia by the beginning of 2021. A Biden administration with a majority in Congress would have substantially more impact (probably a more restrictive one) on the US shale industry than an administration governing through executive orders or other more uncommon instruments like fiscal measures through a Treasury Department under Janet Yellen. That effect could even be fostered by increasing pressure from progressive forces within the party to tighten policies in the event of a congress majority than without one. Being under pressure to fulfill the stark climate policy promise made throughout his campaign, and with a vice-president from fracking-detracting California, especially methane regulations could be tightened. Central federal agencies like EPA will probably revert the direction taken under the previous administration and even will probably even surpass Obama-era undertakings. On the other hand, Biden himself is rather a centrist and is aware of the predominant role US shale has for the country's energy system right now – in particular when it comes to foreign policy issues. The current status of energy independence and diplomatic power through oil & gas exports is a valuable asset which only reluctantly will be given up. Time will prove the considerations made here while their possible impact ranges from little to substantially – based on the proposed future path of the new administration.

2.6. Environmental and societal sustainability – Social license

The environmental and societal hazards of hydraulic fracturing have been covered extensively. On the one hand, systemic environmental risks (Kargbo et al., 2010; Meng, 2017; Wang et al., 2014) include groundwater pollution (Jiang et al., 2011; Osborn et al., 2011; Schmidt, 2011), wastewater issues (Sun et al., 2019), risk to biodiversity for specific species (Kiviat, 2013), and seismic activities (Brudzinski & Kozłowska, 2019; Villa & Singh, 2020). Moreover, risks for human health can occur (Colborn et al., 2011; Schmidt, 2011). Natural gas emissions are fueling climate change, particularly through methane emissions (Gunsch et al., 2019; Stephenson et al., 2011). Depending on the magnitude of methane leaks, its carbon footprint can even be worse than that of other fossils (Alvarez et al., 2018; Howarth, 2019) and needs huge improvements to compete on a sustainable level (Cooper et al., 2018). Those efforts are not materializing yet (IEA, 2020b). On the other hand, groundwater pollution is less of a problem than wastewater disposal, and seismic activities can be mitigated if managed properly (IEA, 2012; Raimi, 2017; Sun et al., 2019). As the EPA (2016) highlights, the conditions for different hazards can vary substantially, and the impacts of shale activities can hardly be generalized (Habrich-Böcker et al., 2015; Mason et al., 2015). Also, if appropriately covered, natural gas' carbon footprint is only half of that of coal and a third less than oil (IPCC, 2014), which is why the rise of the US shale industry is responsible for the country's emission reductions of the last decade (IEA, 2019).

Protests and political opposition against new hydrocarbon projects increased in recent years and examples like the Keystone XL pipeline proved that the social license for such projects cannot always be taken for granted anymore. Movements like “Friday´s for Future” or the “Sunrise Movement” were able to mobilize thousands and to create increased pressure on policy makers. The ban of fracking activities in states such as New York and partly California has shown that such policies have the potential to comprehensively obstruct shale activities. But also in regions more favorable towards shale, expanding regulations (such as banning fracking close to schools in Colorado) make operations more complex.

Multiple scholars have emphasized that for shale’s future prosperity, it’s societal and environmental license is decisive (Marlin-Tackie & Smith, 2020; Wang et al., 2014). Nevertheless, the past decade seems to have proven the contrary for various reasons. While the discussed hazards only partly have been mitigated, the US shale output grew consistently (IEA, 2019). None of these externalities are priced (Mason et al., 2015). Despite their presence, negative externalities require a very high “burden of proof” and fracking’s unpriced social costs are mainly local in nature, while benefits are local, but also national and global (Mason et al., 2015). There is little reason to expect that Covid-19 reverts this trend. Environmental, Social, and Governance (ESG) goals have certainly increased costs for companies, and indeed some – even majors - are struggling with these expenses. Although, it is not entirely consequential why the pandemic would extent the urgency of that aspect. Instead, in times of crisis and economic downturn, many voters and citizens prioritize employment over environmental issues and prioritize sustainability issues to a lesser degree (Abou-Chadi & Kayser, 2017; Kenny, 2020; Singer, 2011). Therefore, although the pandemic offers the chance for societally and environmentally progressive policies (Bodenheimer & Leidenberger, 2020; Helm, 2020), it remains doubtful whether Covid-19 will impact the sustainable license.

3. Methods

The following section discusses the methodology applied to generate the data set for this research. Limitations, which are partly based on the characteristics of the methods, are examined under section 4 “results.”.

3.1. Expert Panel

Great rigor was put into selecting an adequate, nonprobability, and constructivist expert panel, which would be particularly proficient with the topic and represent the full diversity and variety of perspectives eminent in the field (Kruse, 2015). The panel chosen displays an outstanding amount of expertise and unites some senior figures of the target groups. To build this partial census panel, the quota sampling method was applied by segmenting the target population into five fields: Academia/ Research, Industry, Think Tanks, Journalism/ Publishing, and Government/ Public. Multiple strategies, many suggested by Hepburn, O’Callaghan, Stern, Stiglitz, & Zenghelis (2020), were applied to select such a panel. In particular, academics and think tank employees were identified by relevant publications proposed by Drupp, Freeman, Groom, & Nesje (2018). For the latter, the 2019 Global Go To Think Tank Index Report (McGann, 2020) in the categories “environmental” as well as “energy and resources” was consulted. Conference attendants of occasions such as OSEA or LNG2019 were filtered as introduced by Necker (2014) to identify industry experts. The author’s professional network and personal contacts were also used as inferred by Nordhaus (1994). For journalists and publishers, relevant publications and information providers such as the Wall Street Journal, the New York Times, or Bloomberg were scanned. Manual, comprehensive web-based search merged these approaches.

Since the panel is a highly qualified one, the number of participants is not as crucial to ensure data validity as in, e.g., consumer panels (Kruse, 2015). Nevertheless, a sample size of one hundred was the aspired minimum target. Assuming a feedback ratio of around 33% (Stedman et al., 2019) and an error margin of around 10% (e.g., for spelling errors, mails sent to junk folders or outdated addresses, etc.), 400 persons were contacted initially.

3.2. Contact

To ensure sufficient response rates, the principles of Dillman, Smyth, & Christian (2014) laid out the foundation of designing the medium of contact (e-mail) and planning the approaching process. Moreover, following rationales were taken into account to ensure valid response rates. Based on Groves (2006) and Callegaro (2014), the individual benefit for participation was outlined: To gain knowledgeable insights during a period of uncertainty in a field of high familiarity. The sequential mixed mode (start the approach by e-mail and then offer a web-based questionnaire), which was applied here, offers increased response rates compared to traditional mail surveys (Kaplowitz et al., 2004; Medway & Fulton, 2012). The message design attempted a framing as individual as possible (Stedman et al., 2019). This included each recipient's name, title, occupation/ place of work, and recent accomplishments in the field such as publications, if applicable. Johns Hopkins university was highlighted since legitimate organizations increase response rates (Groves, 2006). Survey length and message length were kept as short as feasible (3-4 minutes, 11 questions; 5 lines with a FAQ below) and as self-explanatory as possible (Conelly et al., 2003). An emotional signaling was added ("Do you remember when you were a student?"), and the survey petitioner was lifted out of anonymity by offering contact details and a short CV (Trentelman et al., 2016). Furthermore, ambassadors were utilized to introduce or pass on the questionnaire to colleagues. The survey was conducted between October 20 and November 12, 2020, with three rounds of messages going out to the panel (1 initial and two sets of reminders), which can be found under Appendix B. The detailed questionnaire can be found under Appendix A. Strict anonymity was granted to all participants unless they decided to leave their contact details at the end of the evaluation.

That was not only relevant to increase response rates but also to avoid Common Method Variance (CMV) (Podsakoff et al., 2003).

3.3. Survey Design & Analysis

The cross-sectional expert survey design was based on the work of Bradburn, Sudman, & Wansink (2004) and Diamond (2011) and aimed at collecting a sufficient amount of primary data. The response options were mainly ordinal (with some being nominal), evaluative, and in most cases utilized a Likert scale. An exhaustive item selection to optimize the Likert scale selectivity (Greeving, 2009) was not conducted due to insufficient access to the test population. The online survey done through "Survey Monkey" asked to subjectively assess four central fields of questions: Which main factors are decisive for the future of the US shale industry post-Covid-19 (Q. 1-3)? How do those factors influence the industry (Q. 4)? What (normative) impact will these factors have on the industry recovery post-Covid-19 (Q. 5)? What is a realistic future scenario for the industry (Q. 7-10)? In the end, it also evaluated the background of the survey-takers (Q. 11-12).

The results will be displayed in the shape of tables and diagrams where applicable. With regards to the empirical computations, mainly central tendency (Mode, Median, Mean) as well as spread (Interquartile Range, Standard Deviation) will be conducted. In some cases, a bivariate analysis will be added. Most variables are to be considered ordinal (those of the Likert scales). One exemption displays the first question with including a Likert scale range from 1 to 10 and therefore can be considered continuous (Kampen & Swyngedouw, 2000) for calculations of central tendency. For the benefit of improved comparability, the Likert scales from 1-5 in Q. 4-5 are adapted to a 1-10 scale in the graphics.

4. Results

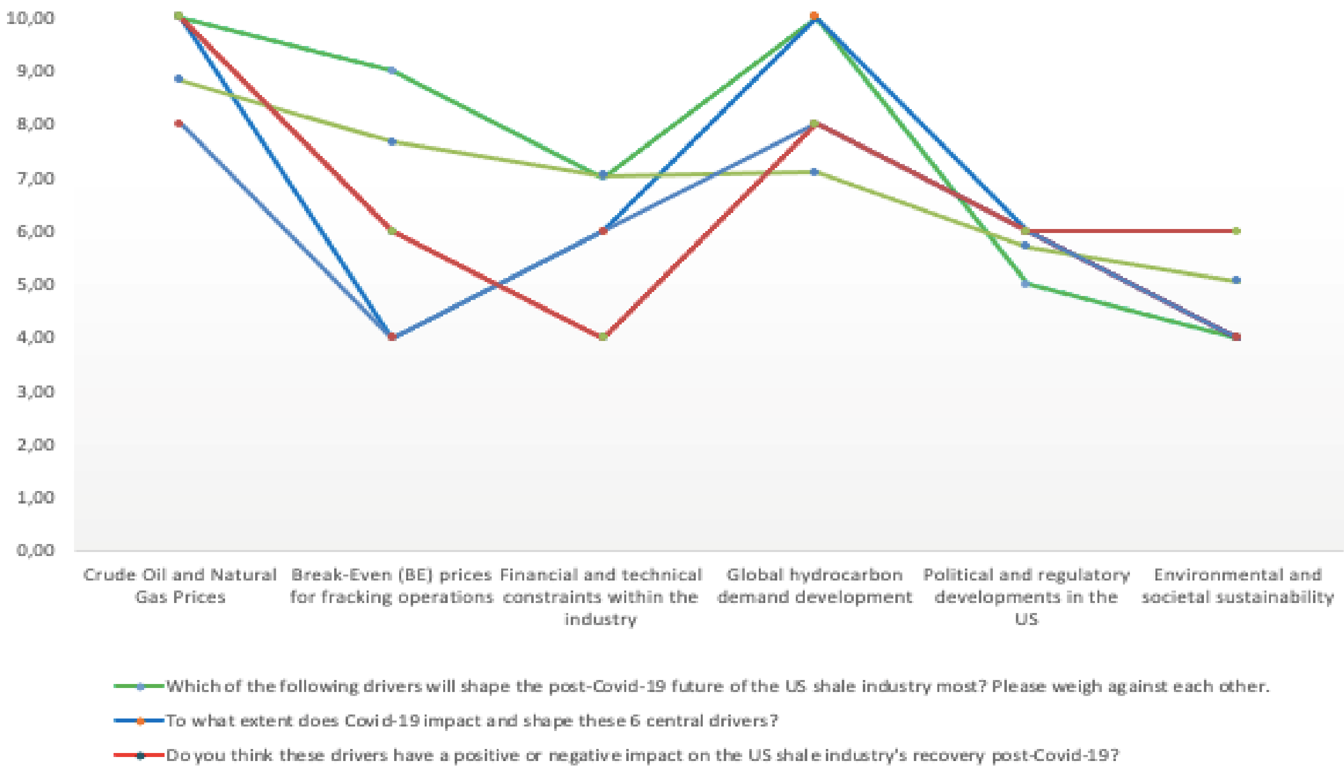
Of those 360 experts contacted, 89 eventually responded. After eliminating incomplete data sets ("Complete Case Analysis"), 83 respondents providing roughly 1,900 data points remained. Further, 63 comments in free space fields were counted. In the following, a closer look into two sections will be conducted: The main drivers impacting the future of US shale (Q. 1-6) and the industry outlook (Q. 7-9). Both are combined with the respondents' backgrounds (Q. 10-11). The section concludes with a debate about research limitations. The detailed results can be found in Appendix C.

4.1. The six central drivers

In terms of importance, the central drivers can be segmented into three groups. First, the expert panel agrees that commodity prices for both oil & gas are the single most important factor, with more than two thirds (71%) rating it as a 9 or 10 out of 10 ($M = 8.82$, $SD = 1.73$) with ten being the highest. The second group consists of the drivers BE ($M = 7.67$, $SD = 2.35$), industry constraints ($M = 7.04$, $SD = 1.95$) and demand ($M = 7.10$, $SD = 2.47$). They are considered as rather decisive. Demand development displays the leading driver, although the spread is somewhat higher than for the first group. Even though global demand and commodity prices are highly interconnected and depend on each other, the experts consider the latter as the more dominant one in this dyad. The least important drivers seem to be political ($M = 5.07$, $SD = 2.08$) and social & environmental ($M = 5.06$, $SD = 2.11$), both being valued 5 out of 10 on average. A similar picture can be seen when it comes to Covid-19 influencing these drivers. The panel seems to agree that commodity prices ($Mdn = 4.00$, $IQR = 1.00$), as well as demand ($Mdn = 4.00$, $IQR = 1.00$), also are the ones which are shaped "a great deal" by the pandemic. Industry constraints ($Mdn = 3.00$, $IQR = 1.00$), as well as political factors ($Mdn = 3.00$, $IQR = 1.00$), are shaped "a lot" by Covid-19 while BE ($Mdn = 2.00$, $IQR = 1.00$) and environmental

& social drivers only are considered to be impacted "a little" on average. Again, a separation into three groups can be observed here, while the macro-economic factors of demand and prices recurrently lead the field in terms of impact. Regarding that impact on the industry recovery being either positive or negative, naturals gas & crude oil prices are considered to affect the post-Covid-19 recovery "very positively" even though the spread of opinions is the starkest here (Mdn 5.00, IQR = 3.00). The same assessment but less distinct can be noted for the demand, which on average is thought of to have a "positive" impact with a considerable spread still apparent (Mdn 4.00, IQR = 2.00). "Neutral" influence is exerted by the drivers BE (Mdn 3.00, IQR = 1.00), political (Mdn =3.00, IQR = 1.00) and social & environmental (Mdn 3.00, IQR = 1.00), while industry constraints have a "negative" impact (Mdn 2.00, IQR = 1.00). Figure 3 visualizes these events, while Table 1 summarizes the overall empirical results.

Figure 3 - *Measures of Central Tendency for the six core drivers (Q. 1-5) - Mean/Median (lighter) as wells as Mode (darker)*



Even though bivariate analyses for a sample size n<100 should only be executed with great caution, for Q. 1 - Q. 5 where n=83, some observations will be made in the following. While for the vast majority of the data set variables only insignificant results are discovered, a few stand out. Table 2 highlights these events. There is a moderate positive relationship between the BE Covid-19 impact (Q. 4) and the BE impact on recovery (Q. 5) with $\varphi = .524$ and χ^2 (16, N= 83) = 22.084; $p < .005$ as well as for natural gas & crude oil prices (Q. 4) and Global demand (Q. 5) with $\varphi = .713$ and χ^2 (16, N= 83) = 42.163; $p < .005$. The same moderate relation applies for political factors (Q. 4) and social/ environmental license (Q. 5) with $\varphi = .781$ and χ^2 (25, N= 83) = 50.620; $p < .005$ and social/ environmental license (Q. 4) to social/ environmental license (Q. 5) with $\varphi = .772$ and χ^2 (25, N= 83) = 49.563; $p < .005$. When it comes to the question of the influence of industry constraints on the US shale industry (Q. 1) and the panel background, a modest relationship is found with 3-22 $\varphi = .481$ and χ^2 (35, N= 83) = 69.694; $p < .005$. Indeed, those experts associated with "industry" and "think tanks/ NGOs" rate the driver as the second most influential one after price development by slight .35 respectively .68 points above the overall average. These groups are probably the most knowledgeable and profound regarding this driver. On the other hand, that driver is rated as the overall second most influential one anyway. A very strong relationship can be found between the impact of political factors (Q. 1) and background where $\varphi = 1.032$ and χ^2 (40, N= 83) = 88.451; $p < .005$. The maximum value is attributed by "Public/ Government with .83 points above the mean, while the minimum comes from "Industry" with .40 points below the mean. Between the variables background and BE (Q. 4) exists a strong relationship with $\varphi = .856$ and χ^2 (25, N= 83) = 60.821; $p < .005$ respectively a moderate relationship (Q. 5) with $\varphi = .691$ and χ^2 (15, N= 83) = 39.536; $p < .005$. No outstanding observations can be made for these connections. Last but not least, global demand (Q. 5) has a significant relationship with all other variables covered. Reflecting on the associations presented so far as well as the tendencies summarized in Figure 3, the following assumption seems plausible: Those drivers who are considered to shape the future of the US shale industry the most also are the ones which are affected the greatest by Covid-19 while those are also expected to shape the industry recovery the in a positive way – and vice versa.

Table 1 - *Empirical survey results summarized*

Q. 1 Drivers	Prices	BE	Constraints	Demand	Political	License
1 - not at all	1	1	0	0	0	3
2	1	5	0	5	4	1
3	0	1	1	6	12	17
4	2	2	11	3	5	19
5	1	5	9	6	19	14
6	1	6	10	6	18	6
7	3	9	16	21	7	11
8	13	14	14	9	8	4
9	25	21	12	6	7	7
10 - a great deal	36	19	10	21	3	1
Mean	8,82	7,67	7,04	7,10	5,70	5,06
Mode	10,00	9,00	7,00	10,00	5,00	4,00
Standard Deviation	1,73	2,35	1,95	2,47	2,08	2,11
Q. 4 Driver Impact	Prices	BE	Constraints	Demand	Political	License
1 - not at all	4	11	4	0	11	18
2	4	37	15	5	29	32
3	5	14	29	14	32	19
4	31	14	24	28	8	10
5 - a great deal	39	5	10	35	2	3
Median	4,00	2,00	3,00	4,00	3,00	2,00
Mode	5,00	2,00	3,00	5,00	3,00	2,00
Interquartile Range	1,00	1,00	1,00	1,00	1,00	1,00
Q. 5 Driver normative	Prices	BE	Constraints	Demand	Political	License
1 - very negative	5	0	4	1	2	3
2 - negative	18	8	42	27	30	35
3 - neutral	15	36	24	11	40	30
4 - positive	0	30	10	30	8	11
5 - very positive	45	9	2	14	3	3
Median	5,00	3,00	2,00	4,00	3,00	3,00
Mode	5,00	3,00	2,00	4,00	3,00	2,00
Interquartile Range	3,00	1,00	1,00	2,00	1,00	1,00

Q. 6- US Election	Absoute	Relative
1 - not at all	5	6%
2	28	34%
3	29	35%
4	15	18%
5 - a great deal	6	7%
Median	**3,00**	
Mode	**3,00**	
IQR	**1,50**	
Q. 7 Shale future	Absoute	Relative
1 - Pessimistic	12	14%
2 - Neutral	48	58%
3 - Optimistic	23	28%
Median	**2,00**	
Mode	**2,00**	
IQR	**1,00**	
Q. 8 - Recovery Pre-Covid?	Absoute	Relative
1 - No	26	31%
2 -Uncertain	19	23%
3 - Yes	38	46%
Median	**2,00**	
Mode	**3,00**	
IQR	**2,00**	
Q. 10 Background	Absoute	Relative
Journalism/ Publishing	7	8%
Academia/ Research	30	36%
Industry	20	24%
Think Tank / NGO	9	11%
Public/ Government	7	8%
Other	10	12%
Q. 11 - Time in Industry	Absoute	Relative
0-5 years	21	25%
5-10 years	35	56%
10+ years	27	100%

Table 2 - *Bivariate Analyses: Cross-tabulation & the chi-square overview for all significant relationships of the data set*

Variable 1	Variable 2	φ	relationship	χ^2	p-value
BE Q. 4 (Variable 8)	BE Q. 5 (Variable 14)	.524	moderate	(16, N=83) = 22.084	< .005
Commodity Prices Q. 4 (Variable 7)	Global demand Q. 5 (Variable 16)	.713	moderate	(16, N=83) = 42.163	< .005
Political factors Q. 4 (Variable 11)	Social/ environmental license Q. 5 (Variable 18)	.781	moderate	(25, N=83) = 50.620	< .005
Social/ environmental license Q. 4 (Variable 12)	Social/ environmental license Q. 5 (Variable 18)	.772	moderate	(25, N=83) = 49.563	< .005
BE Q. 5 (Variable 14)	Recovery Outlook (Variable 21)	.481	modest	(6, N= 83) = 19.224	< .005
Industry Constraints Q.1 (Variable 3)	Background (Variable 22)	.481	modest	(35, N= 83) = 69.694	< .005
Political factors Q.1 (Variable 5)	Background (Variable 22)	1.032	very strong	(40, N= 83) = 88.451	< .005
BE Q. 4 (Variable 8)	Background (Variable 22)	.856	strong	(25, N= 83) = 60.821	< .005
BE Q. 5 (Variable 14)	Background (Variable 22)	.691	moderate	(15, N= 83) = 39.536	< .005
Recovery Outlook (Variable 21)	Experience (Variable 23)	.508	moderate	(4, N= 83) = 21.383	< .005
Global Demand Q. 5 (Variable 16)	All other variables				< .005

When it comes to the 2020 US election's influence, the panel rates its importance as being moderate with a tendency to only be of little importance (Mdn 3.00, IQR = 1.50). Even though, it must be mentioned that only six responses (7%) were collected after the election date of November 3, when it became clear or foreseeable that a change in government would take place.

4.2. US shale Outlook

When it comes to the industry outlook, most panel members are neutral (53%), although slightly more than a quarter (28%) project a positive future scenario. While these shares do roughly align for the “Industry” group, they are slightly different for “Academia/ Research”, which displays the largest group of respondents. Within this segment, almost half (47%) consider a neutral scenario, but also the share of those expecting a positive future is way higher (40%). Similarly, the segment of “Public/ Government” draws a relatively positive picture: Substantially more than half of the experts from that field consider the outcomes as “positive “(57%) or at least neutral. Generally, almost half of the experts (47%) expect the US shale industry to recover to pre-Covid-19 levels while around a quarter (23%) are neutral, and a third deny such a recovery (31%). Similar numbers can be seen again for the “Public/ Government” segment, which makes both groups the more optimistic ones. The groups that present the most positive future assessments were “Public/ Government” with 10+ years of industry experience and “Academia/ Research” with 5-10 years of experience. Vice versa, the most negative ones are experts from “Think Tanks/ NGOs” with 10+ years as well as “Industry” professionals with 0-5 years. Figure 4 gives an overview of these connections.

In terms of bivariate analyses, a modest relationship can be noted between the BE impact on recovery (Q. 5) and the recovery outlook with $\varphi = .481$ and χ^2 (6, N=83) = 19.224; $p < .005$. Another, moderate, relation can be observed between the panel background and the question about shale recovery. While two thirds (67%) of those with the least experience in the industry say that the industry will recover, only one in ten (11%) of those with 10+ years of experience do so. In that group, almost half (48%) think that a recovery to pre-Covid-19 levels will not occur.

Figure 4 - *Frequency distribution of US shale outlook (Q. 7-8) in contrast to panel backgrounds (Q. 10- 11)*

4.3. Repercussion on the hypotheses

4.3.1. *Hypothesis 1*

Those drivers influencing the industry's future the most as well are the ones being affected the most by Covid-19. Segmenting into three groups as suggested, the two most influential drivers of oil & natural gas prices and demand (M 8.00, SD = 2.1) are considered to be shaped “a lot” by the industry (Mdn 4.00, SD = 1) but also are considered to have a positive influence on the recovery of the industry (Mdn 4.5, SD = 2). Although it should be mentioned that keeping in mind a comparably high spread, opinions seem to diverge slightly. Most drivers are expected to shape the industry by a “moderate” amount while their normative impact is predominantly considered “neutral”. Also, the majority of the panel (58%) is neutral about the future of the industry while almost a third is rather optimistic (28%). The preceding result description highlighted that the results are interconnected and often dependent on the background of the panel takers. The results do not point in one direction or another. Nevertheless, choosing between the Hypothesis H_1 and the Null-Hypothesis H_0, the impacts of Covid-19 are not precisely negative but rather depend on single drivers and could therefore constitute in a different direction. Incorporating the criticism of picking one of both options (Biemann, 2009), H_0 seems more reasonable.

4.3.2. *Hypothesis* 2

The observations discussed for Hypothesis 1 are also partly applicable to Hypothesis 2. Most relevant drivers do not point in a direction that would draw a necessarily pessimistic future scenario for the US shale industry. Turning to Q. 8, almost half of the experts state they expect a recovery to pre-Covid-19 levels (47%) while roughly a quarter is uncertain about that (23%), leaving those not expecting a recovery to 2019 levels as the minority. A biased panel (further discussed in section 4.4) might apply but is only in parts responsible for these result’s overall message of. For Hypothesis 2, it seems to be even more apparent that H_0 is the more applicable option to apply: 2019 was an all-time industry high, which could be reached again.

4.4. Limitations

Since the survey was designed to optimize response rates, it did not allow an in-depth assessment of single parameters. Although blank fields enabled the participants to specify their evaluation and to add comments, the strict design might have fostered generalization at some points. A key area where more in depth evaluation would have been helpful is the time horizon of the driver implications. Furthermore, the background of the target population assessed does not have the same balanced split of the target population contacted. The panel which participated in the study is mainly originated within Academia/ Research (38%) or the Industry (25%). That could have translated into response biases (Diamond, 2011; Stedman et al., 2019) based on the corresponding professional perspective. And even within one field, opinions certainly divert. Both investors and operators would probably identify themselves with the field "Industry" but naturally have diverging points of view.

The selection process certainly did not involve or even identify all relevant experts in the field, particularly for those not located in the US. An exhaustive representation of all opinions eminent might be limited by that element and incorporate "single source biases". Although the analysis conducted in section 4.2 does not necessarily support such an objection. Research fatigue is an issue that leads to lower survey outputs and lower response quality (Walsh et al., 2020). Especially in times of high uncertainty as during the Covid-19 pandemic and while the test population is exposed to frequent polls (such as the Dallas Fed Oil & Gas Survey), this is a threat to research. The return rate of this assessment, which turned out lower as intended, highlights that issue. Reliability and generalizability might be affected by these factors. Finally, the bivariate analysis completed through cross-tabulation and the chi-square test in this work offers some points of uncertainty. As noted before, the target population is too small to compute in-depth empirical research. Looking at the results, some appear meaningful and fit the picture drawn by the dissimilar results (e.g., the relationship between variable 3 and 22 industry constrains and background, or between variable 7 and 16 commodity prices and global demand). Others, like the correlation of variable 16 global demand, question the overall (construct) validity of that measurement tool. Therefore, these outcomes can only be taken as an indicator and not as significant effects shaping the result considerations.

5. Discussion

Through the course of the last section, it became clear that the quantitative analysis in the shape of an expert survey resulted in a different assessment on the impact of Covid-19 and its impact on the US shale industry than the preceding literature review. The proposed hypotheses formed by the literature review were rather rejected than confirmed. The overall outlook for the industry looks rather promising than doubtful. Although, noticing a relatively high spread throughout the data set, it also became clear that opinions diverted. Moreover, the time horizon of these developments was not covered in great depth. It remains unclear if a possible recovery to pre-crisis levels will take place in a more medium or long-term scenario. The expert background mattered in some instances like the assessment of the political driver and the limitations discussed in section 4.4 highlight the necessity to interpret these outcomes with greatest caution. The drivers examined are all interconnected and influence each other, the best example are prices and demand. Isolated analyses of single factors will necessarily distort the image and lead to wrong conclusions. Uncertainty about the short-medium term future is a reoccurring pattern. Single, unforeseeable developments might result in entirely different scenarios that neglect all discussions held in this paper. However, the following considerations are worth taking into account.

It became clear throughout this study that most relevant drivers are substantially shaped by the development of the Covid-19 pandemic and its repercussions on the global economy. Although the pandemic's advance displays a first layer of uncertainty, it seems that after a second partial lockdown in late fall 2020 and with vaccinations to be started by the end of 2020, 2021 could become the year in which the disease will be at least contained. However, multiple scenarios for economic recovery can be expected. The IMF (2020) expects marginalized growth in 2021 and an arduous recovery in the long-term. Nakamura, Steinsson, Barro, & Ursúa (2013) have highlighted that looking at all large economic crises, historically, it took 6-7 years on average to return to pre-crisis levels. For the major banking crises that have occurred in the last 150 years, the median amount of time was 6.5 years (Reinhart & Rogoff, 2014). Economic shocks are not just temporary disruptions but can have meaningful and lasting impacts on economic performance (Cerra & Saxena, 2008; Larsen et al., 2020). Looking at the finance industry after 2008, it also becomes clear what transformative potential such a crisis can have on an industry. Although for the case of hydrocarbons, demand will recover, the current crisis will not withdraw without leaving its marks.

When it comes to the driver natural gas and oil prices, it is amongst the most important or even the single most crucial factor for the industry's future. Both the literature and this study agree that the impact of Covid-19 on prices is significant (Sharif et al., 2020). Also, it is deeply bound to the question of global demand development. Increasing demand essentially results in increasing prices if the supply does not expand at the same rate and disturbs that interplay. Both are closely directed by the economic recovery scenario of whatever shape (L, V, W curve) eventually taking place (Larsen et al., 2020). More than the overall recovery, particularly rebound in specific industries, predominantly transportation, will decide about demand and prices.

Although not being the primary driver influencing the industry, industry constraints continue to be relevant. The discussion has not changed much for the last decade (Gao & You, 2017; Wang et al., 2014), but the pandemic has tightened the margin for error here. While investor money is becoming scarcer, and the focus shifts more to profits and capital discipline focusing on growth, capital requirements keep being high. Many companies struggle as a result– not just medium-sized companies but also IOCs active in the shale business. The trend towards bankruptcies and industry consolidation is likely to proceed. Especially smaller companies less capable of surviving times of financial hardship are attractive short-cycle acquisition targets. Also, companies will continue to lower BE costs (Rystad Energy, 2020). Technical solutions like refracturing will be key to moving forward (Kong, Ostadhassan, Tamimi, Samani, & Li, 2019), although the innovation path curve effect makes technological progress less impactful but more expensive. That threatens future competitiveness. Being one of the industry's biggest pain points, this study also highlights that industry constraints are probably the most negative influence on the industry's future.

The political and environmental/ social license drivers seem to be interconnected, which is logical in the context of policy fields influencing policymakers and rulemaking. It is particularly interesting to see that the political aspect and in particular the outcome of the 2020 US presidential elections are not expected to have a decisive influence on the industry in this assessment. Other evaluations, like the Dallas Fed Energy Survey (Dallas Fed, 2020), take that into account by valuing the political factor more prominently. A reason why this study comes to a different conclusion might be that the new administration has not announced concrete policies which substantially affect the industry. Another motive might be that the shale industry can be considered as so incrementally important for the US in multiple ways that it is unlikely that too punitive policies would be introduced anytime soon. It needs to be highlighted that some of the factors discussed in 2.5 have the potential to be disruptive. The often discussed repercussions of the social/ environmental license have not yet materialized to shake the industry, and the results of this study do not support any different interpretation. For both drivers, it is important to note what Sovacool (2014) underlined: “The pursuit and utilization of shale gas presents policymakers, planners, and investors with a series of pernicious tradeoffs and tough choices”. It seems that this balancing act has been managed satisfyingly for the greatest part in the past since no regulations or policies have fundamentally opposed the industry yet. Many shale threats have been mitigated by rulebook in the last decade (IEA, 2012).

This paper discussed the plunge of oil prices by the beginning of 2020 and Saudi Arabia ‘s and Russia’s involvement. While neither of their economies, like the US shale industry, can survive at very low prices for an extended time (Sabitova & Shavaleyeva, 2015), it also made another issue quite visible: Another layer of uncertainty is added whether a major conflict will occur that could dramatically change the stability of world oil markets or not (Jefferson, 2020). Generally spoken, the cause of the current particular downturn is quite unique, but shocks to the market are not. 2020 displayed the third major price collapse in 12 years. Generally, commodity markets are a cyclical business: Oil markets will stay volatile (Michaux, 2019). After the last two price shocks, US shale has proven to be remarkably resilient (especially in the Permian), and its rebound set US production on the top.

While valid arguments can be offered in favor and against the future of the industry, the experts asked throughout this study are rather restrained about its future: Most think “neutrally” about it. Although, different to, e.g. the Dallas Fed Oil & Gas survey, the biggest group expects a recovery to pre-Covid-10 levels. Although, a recovery to pre-Covid-10 levels does not necessarily mean equal growth trajectories as prior to the pandemic. Still, it is a reasonable opinion in a world that still covers around 80% of its energy demand (IEA, 2020b) with fossil fuels and therefore depends on US exports, which are gained from shale formations for the greatest parts. Shale has gained its place in the energy landscape and is unlikely to vanish soon. Some even say that fracked natural gas has the potential to become the world's primary energy source (Kan et al., 2020; Liew et al., 2020). While there lies truth in this statement for gas, it is less valid for oil. It is under pressure especially due to a transforming transportation sector and its shifting focus to EVs. Leveraged Costs of Energy (LCOE) for renewables are increasingly competitive (EIA, 2020a) and compete against fossils in sectors such as heating, power generation and partly transportation (Ram et al., 2018). The low carbon transition gains traction, and today's energy landscape is unimaginable without the link to its emissions. Therefore, gas might face the same situation in thirty years as oil does in the next decade. The current pandemic may even accelerate the energy transition and decarbonization. Some scholars underlined that "Green Stimulus" after the crisis would add more economic growth than traditional measures (Hepburn et al., 2020).

6. Conclusion

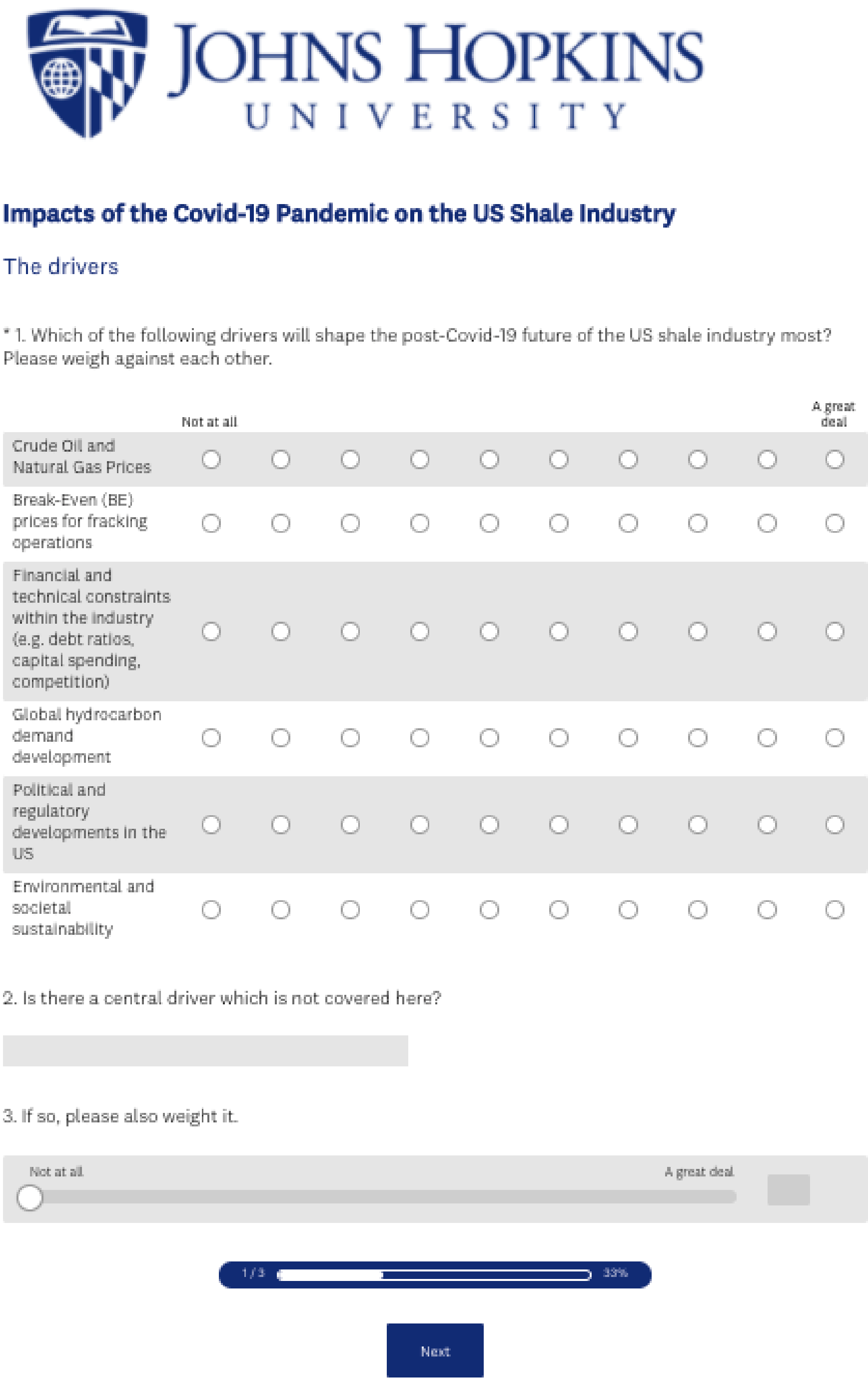
This study focused on six central drivers to evaluate the 2020 Covid-19 pandemic impact for the US shale industry. These were: First, crude oil and natural gas prices. Second, Break-Even (BE) prices for fracking operations. Third, financial and technical constraints within the industry (e.g., debt ratios, capital spending, competition). Fourth, global hydrocarbon demand development. Fifth, political and regulatory factors in the US. Sixth, environmental and societal sustainability. While prices and demand seem to be the most impactful ones, it needs to be highlighted that these drivers are highly interconnected and exert influence between each other. Isolated analyses of single drivers will almost necessarily lead to wrong conclusions. The expert survey seems to agree that the more impactful the drivers are, the more they seem to be shaped by Covid-19 – and the more those influence the future of the industry positively. Although, it also has to be mentioned that opinions sometimes divert, and the partly insufficient database makes the results not always reliable. That leads the quantitative results of this work to give some valuable insights and directions but should not be considered the single truth. In the literature review as well as in the quantitative part, uncertainty runs like a golden thread through the analyses. Especially the literature review highlights the multiple factors influencing each driver which makes a projection about the future of the US shale industry a highly complex maneuver. While some mega-trends proceed (e.g., energy transition, energy demand growth, low-carbon-economy), the pandemic displays an unprecedented crisis with parameters almost impossible to foresee. While the experts in this study are fairly optimistic that the industry will recover to pre-Covid-19 levels, the general outlook for the future is a little bit less optimistic. Also, gas is advantaged in comparison to oil. As the EIA (2020a) underlines, energy market projections are always subject to much uncertainty because the various elements that shape markets, as well as future advances in technologies, demographics, and resources, cannot be projected with certainty. That is even more true for the current situation. Nevertheless, this work aims to pull its weight to understand better what a possible future of the US shale industry could look like. A future, that is highly uncertain but within certain boundaries will probably favor the US shale industry.

References

Appendix

Appendix A

Online questionnaire illustration.


JOHNS HOPKINS UNIVERSITY

Impacts of the Covid-19 Pandemic on the US Shale Industry

The drivers

* 1. Which of the following drivers will shape the post-Covid-19 future of the US shale industry most? Please weigh against each other.

	Not at all									A great deal
Crude Oil and Natural Gas Prices	○	○	○	○	○	○	○	○	○	○
Break-Even (BE) prices for fracking operations	○	○	○	○	○	○	○	○	○	○
Financial and technical constraints within the industry (e.g. debt ratios, capital spending, competition)	○	○	○	○	○	○	○	○	○	○
Global hydrocarbon demand development	○	○	○	○	○	○	○	○	○	○
Political and regulatory developments in the US	○	○	○	○	○	○	○	○	○	○
Environmental and societal sustainability	○	○	○	○	○	○	○	○	○	○

2. Is there a central driver which is not covered here?

3. If so, please also weight it.

Not at all — A great deal

1 / 3 33%

Next

Impacts of the Covid-19 Pandemic on the US Shale Industry

Covid-19 and the 6 central drivers' impact

4. To what extent does Covid-19 impact and shape these 6 central drivers?

	A great deal	A lot	A moderate amount	A little	None at all
Crude Oil and Natural Gas Prices	○	○	○	○	○
Break-Even (BE) prices for fracking operations	○	○	○	○	○
Financial and technical constraints within the industry (e.g. debt ratios, capital spending, competition, consolidation)	○	○	○	○	○
Global hydrocarbon demand development	○	○	○	○	○
Political and regulatory developments in the US	○	○	○	○	○
Environmental and societal sustainability	○	○	○	○	○

5. Do you think these drivers have a positive or negative impact on the US shale industry's recovery post-Covid-19?

	Very positive	Positive	Neutral	Negative	Very negative
Crude Oil and Natural Gas Prices	○	○	○	○	○
Break-Even (BE) prices for fracking operations	○	○	○	○	○
Financial and technical constraints within the industry (e.g. debt ratios, capital spending, competition, consolidation)	○	○	○	○	○
Global hydrocarbon demand development	○	○	○	○	○
Political and regulatory developments in the US	○	○	○	○	○
Environmental and societal sustainability	○	○	○	○	○

* 6. To what extent does us shale recovery post Covid-19 depend on the outcome of the 2020 presidential election?

A great deal	A lot	A moderate amount	A little	None at all
◯	◯	◯	◯	◯

* 7. Are you pessimistic, neutral, or optimistic about the future of US shale?

◯ Pessimistic

◯ Neutral

◯ Optimistic

* 8. Do you think that the US shale industry will recover to pre Covid-19 levels?

◯ Yes

◯ No

◯ Uncertain

9. Is there anything which you think was overseen in this survey or you want to add?

2 / 3 67%

Prev Next

Impacts of the Covid-19 Pandemic on the US Shale Industry

Last but not least ... About you

* 10. What is your background in terms of US shale proficiency?

◯ Academia/ Research

◯ Industry

◯ Think Tank / NGO

◯ Journalism/ Publishing

◯ Public/ Government

◯ Other

11. What´s your length of experience in the US shale industry?

- ◯ 0-5 years
- ◯ 5-10 years
- ◯ 10+ years

12. In case you want to be kept updated on the progress of this research: Please fill in contact details here:

Name

Company

Country

Email Address

* 13. I agree to the survey´s T&Cs

☐ Agree

3 / 3 100%

Prev Submit

Appendix B

Contact E-mail asking for participation in the expert survey.

Dear «Salutation» «Surname»,

You are invited to participate in a survey on the future of US shale post COVID-19.

The future of the US shale industry post Covid-19 is characterized by uncertainty, but your input can help to draw a much clearer picture. You certainly remember how helpful expert knowledge was for your research when you were a student.

As an expert in this field, I ask you to participate in this **3 minute survey** I am conducting as part of my **Capstone Project** at **Johns Hopkins University**. I know that your time is rare. Below you can find in depth information, otherwise please just go ahead and take part in this assessment:

https://www.surveymonkey.de/r/CoronaAndUSShale_Hopkins

I appreciate your time and effort a lot! Yours sincerely,

Nikolai Albishausen
nikolai@jhu.edu; +49 17672979212

Advisor: Prof. Zachary
d.s.zachary@jhu.edu

PS: Please feel free to forward this message to colleagues as you see fit.

Appendix C

Summarized, detailed response data from the expert survey.

Which of the following drivers will shape the post-Covid-19 future of the U						To what extent does Covid-19 impact and shape these 6 central						Do you think these drivers have a positive or negative impact on						To what e:	Are you pe	Do you thi	What is yo	What´s yo
Crude Oil and N	Break-Even	Financial a	Global hyd	Political an	Environme	Crude Oil	Break-Eve	Financial a	Global hyd	Political an	Environme	Crude Oil	Break-Eve	Financial a	Global hyd	Political an	Environme	Response	Response	Response	Response	Response
7	6	7	6	6	4	5	4	5	4	4	5	5	4	5	4	5	4	4	3	1	Journalism	0-5 years
8	5	7	6	8	5	4	3	4	4	4	1	1	2	2	4	1	4	4	2	1	Other	0-5 years
2	3	3	2	2	3	5		3	5	5	5	5	4	3	4	3	4	4	1	1	Public/Gov	5-10 years
4	2	6	2	6	1	4	2	3	4	1	1	5	4	2	3	2	2	4	2	3	Journalism	5-10 years
10	8	7	10	5	7	5	1	4	5	2	2	1	3	2	2	3	3	1	3	2	Academia/	5-10 years
9	8	4	7	5	6	5	1	3	4	2	3	5	4	2	4	2	3	2	2	1	Other	0-5 years
9	9	8	5	7	4	2	3	2	2	2	2	1	3	3	3	3	3	3	1	3	Academia/	0-5 years
10	10	10	10	6	5	4	1	2	4	3	3	5	3	3	5	5	2	2	1	3	Think Tank	10+ years
9	6	9	10	5	6	5	5	4	5	3	2	5	5	2	2	3	2	3	2	3	Academia/	0-5 years
10	5	8	10	5	8	1						2	2	2	1	2	2	3	2	3	Academia/	10+ years
10	10	8	8	3	3	5	2	5	5	3	2	5	4	2	4	4	4	3	3	3	Academia/	5-10 years
9	9	10	7	7	7	5	3	3	5	3	2	2	3	1	2	3	3	3	2	1	Think Tank	5-10 years
9	7	8	5	3	5	5	2	4	4	3	2	5	5	2	4	2	2	2	2	3	Academia/	10+ years
9	8	6	6	4	3	4	2	3	5	4	3	5	4	3	4	2	2	2	3	3	Public/Gov	10+ years
9	9	6	10	3	3	4	4	3	5	1	1	3	4	4	5	3	3	2	2	2	Industry	10+ years
7	7	4	7	9	7	5	5	5	5	3	3	3	3	2	3	2		3	3	3	Academia/	5-10 years
8	8	4	7	7	4	4	4	2	4	3	3	5	4	3	4	3	2	2	2	1	Journalism	0-5 years
10	8	8	10	5	7	4	2	3	4	3	4	2	2	2	2	3	2	3	1	1	Journalism	5-10 years
10	10	7	8	9	1	4	2	3	3	4	4	5	2	3	2	3	5	5	2	1	Other	0-5 years
9	9	10	2	8	4	5	4	5	3	3	4	5	3	2	4	3	1	3	2	2	Industry	0-5 years
10	10	6	7	6	4	5	2	4	4	3	2	5	4	4	5	3	3	3	1	1	Industry	0-5 years
8	9	5	5	5	9	5	3	5	5	3	3	5	4	3	2	3	2	3	2	3	Academia/	5-10 years
10	8	9	8	9	9	5	2	4	5	3	4	2	3	3	2	2	2	2	2	3	Academia/	5-10 years
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10	10	8	10	8	8	4	4	2	4	2	2	3	3	3	3	3	3	4	3	3	Public/Gov	5-10 years
9	9	7	9	5	5	5	3	3	5	2	2	5	5	3	4	3	3	2	3	2	Academia/	10+ years
10	6	5	3	3	4	3	2	3	3	2	2	5	3	4	4	4	4	1	3	3	Academia/	10+ years
9	2	9	3	6	4	4	2	4	2	2	2	5	4	2	4	2	2	4	2	2	Industry	10+ years
9	5	9	9	5	4	5	2	4	5	2	2	2	3	2	4	2	2	2	1	1	Academia/	0-5 years
10	7	5	7	3	5	1	2	4	3	1	1	2	3	2	2	2	3	2	2	2	Industry	10+ years
10	9	10	10	10	7	4	4	4	4	3	1	5	4	2	5	2	2	5	2	2	Public/Gov	5-10 years
8	7	9	7	6	9	4	2	3	3	2	2	5	3	2	4	4	4	3	2	3	Industry	5-10 years
10	9	8	7	5	4	5	1	3	4	3	3	2	3	2	2	3	3	2	2	3	Other	5-10 years
10	9	7	4	2	3	4	2	2	5	1	1	5	4	2	5	3	3	4	2	1	Industry	10+ years
10	10	4	7	5	5	4	2	1	4	2	2	5	4	2	5	3	3	4	2	2	Academia/	10+ years
10	10	6	9	6	3	2	2	2	4	2	1	3	3	3	4	2	2	3	2	3	Think Tank	5-10 years
10	1	4	8	4	3	5	5	4	5	1	1	3	3	3	4	1	1	3	2	3	Other	0-5 years
8	10	10	10	6	3	4	3	3	4	3	2	5	4	2	2	2	3	4	3	3	Industry	5-10 years
10	6	8	10	3	3	4	2	2	5	2	2	2	4	2	2	3	3	2	3	3	Academia/	5-10 years
8	7	9	7	9	9	5	2	4	5	4	3	1	4	1	2	2	2	3	3	2	Industry	10+ years
9	4	8	6	6	5	5	3	5	4	3	4	2	2	2	2	3	2	2	1	1	Think Tank	0-5 years
8	8	5	8	6	5	3	2	4	3	2	2	3	3	2	3	2	2	3	3	2	Think Tank	5-10 years
8	9	7	7	6	3	3	3	2	3	2	1	3	3	3	2	3	2	2	2	1	Academia/	10+ years
9	9	9	6	8	8	5	3	3	5	2	3	5	5	4	5	4	4	3	3	3	Academia/	5-10 years
10	9	7	7	8	7	4	2	2	3	2	1	5	4	4	3	4	4	2	3	1	Academia/	5-10 years
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8	10	10	8	7	5	5	3	3	5	3	2	5	4	4	4	3	3	5	3	3	Industry	10+ years
9	8	5	3	6	4	5	2	4	5	2	2	3	3		4	2	2	4	2	1	Industry	5-10 years
5	10	4	4	4	4	3	1	3	3	3	3	3	5	3	3	3	3	3	2	2	Academia/	5-10 years
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10	10	10	10	6	5	4	1	2	4	3	3	5	3	3	5	5	2	2	1	3	Think Tank	10+ years
9	6	9	10	5	6	5	5	4	5	3	2	5	5	2	2	3	2	3	2	3	Academia/	0-5 years

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